



Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

THE RELATION OF FATIGUE TO INDUSTRIAL ACCIDENTS—*Concluded*

EMORY S. BOGARDUS
The University of Chicago

V. ACCIDENT-HOURS

Reference is made in Section III to a study of accident records (State of Illinois for the year 1910) which has been made by the writer. It will be recalled that of the accident reports examined, 2,687 gave a fairly accurate description of what happened preceding the given accidents; and 2,203 or 82.2 per cent of the 2,687 accidents conceivably might have been avoided if the injured or the fellow-servant, who was the cause of the accident in some cases, had had accurate muscular control. Of the 2,203 accidents which might have been avoided, the time at which 2,162 of these occurred was given. These reports were tabulated according to the hours of the day, and the results appear in Table V. In general, there is *a rise in the number of accidents during the forenoon, a decided fall after the noon period of rest, and another rise in the afternoon hours.* Further

TABLE V
ACCIDENT-HOURS (ILLINOIS, 1910)

Morning	Accidents	Afternoon	Accidents
7 to 7:59.....	79	1 to 1:59.....	111
8 to 8:59.....	150	2 to 2:59.....	156
9 to 9:59.....	193	3 to 3:59.....	227
10 to 10:59.....	246	4 to 4:59.....	260
11 to 11:59.....	257	5 to 5:59.....	145
12 to 12:59.....	49	Other hours.....	289

conclusions must be withheld until certain factors are considered. A vital point is to be found, not in the number of accidents per hour, but in the number of accidents per hour during a period when the same number of employees are at work.

The figures given in Table V represent factories in which the working hours are not similar. While in general the working day is from 7 A.M. to 6 P.M. with a rest period from 12 M. to 1 P.M. in the factories to which the statistics in Table V apply, there are important variations. In many factories especially where women are employed, the day begins at 7:30 A.M. The time of the lunch period at noon varies—in one plant employing about 3,000 men and women, the writer found that practically one-half of this number take their lunch period from 11:30 to 12. Frequently the employees begin their afternoon period of work at 12:45 P.M., and in some cities at 12:30 P.M. In the large cities the working day closes in a considerable number of cases at 5:30 P.M. or 5 P.M.; and if there is Saturday afternoon work, at 4 P.M. A study of the work-hours of the factories to which the figures in Table V apply shows that from 7 A.M. to 8 A.M., from 11 A.M. to 1 P.M., and after 5 P.M. a lesser number of employees are at work than during the other work-hours, when the employees of all the factories represented are considered in the aggregate. If the table shows a smaller number of accidents during the hour from 7 to 8 A.M. than in the succeeding hour, it is not safe to infer that the danger of accident is correspondingly less, since a smaller number of persons are at work from 7 to 8 A.M. than during the following hour. In Table V the periods from 8 to 11 A.M. and from 1 to 5 P.M. are *of almost uniform employment*.

In considering this period of uniform employment the rate of work must be taken into account before definite conclusions may be drawn regarding the influence of fatigue. As pointed out in Section IV, the greater the speed of work, the greater is the danger of accident, and vice versa. Hence the question arises: Is the rate of work uniform in connection with dangerous machinery?

In a recent investigation by the United States Bureau of Labor, records were taken from hour to hour from stamping presses equipped with automatic counters for registering the production. Records were kept for twenty-three machines for periods varying from one day to seven. With reference to the

results, the report of the Bureau of Labor says that it is extremely probable "that there is an average slackening of activity on the part of the workers in the last hour and a half of the day."¹ If this explanation be correct and be applied to the afternoon period of uniform employment from 1 to 5 P.M., it will be seen that the last hour from 4 to 5 P.M. is probably one during which the rate of activity is much less than during the preceding hours. In general and on the average it may be assumed that the afternoon period from 1 to 4 P.M., like the forenoon period from 8 to 11 A.M., is one of both *uniform employment* and of *fairly uniform rapidity of work*.

From each of the three-hour periods of both uniform employment and rapidity of work three other factors have been eliminated: (a) During the last half-hour of work before noon and before the time for closing there is likely to occur what is called the "final spurt," which comes with the realization that one's work is nearly finished and which tends to reduce the danger of accident because of the increased volitional forces brought to bear upon the work. (b) The close of the working period is to some extent a period of readjustment—accumulated work is removed; new stock is secured in order that the next period of activity may go forward unhindered.² (c) There enters also the sense of accomplishment. The worker may proceed more leisurely to the close of the period, after he has accomplished a certain amount of work and has his task well in hand.³

The question arises: How do the afternoon totals compare with the forenoon totals? But an adequate basis of comparison is not present. In the first place, the forenoon period is often longer than the afternoon period. Further, it is not correct to compare the totals for the hours from 1 to 4 P.M. with those from 8 to 11 A.M. because the existence of a Saturday half-holiday during the summer, and in some trades throughout the year, depresses the afternoon totals, while a high number of accidents on Monday mornings after the Sunday holiday unduly increases the forenoon totals. Also, the evidence indicates that the rapidity

* Quoted from proof-sheets of Vol. XI of the "Report on Condition of Woman and Child Wage-Earners in the United States," Senate Doc. No. 645, 61st Cong., 2d sess.

¹ *Ibid.*, Vol. I, 395.

² *Ibid.*

of work is considerably lessened in the last hour and a half of the day's work and the chances of accident are correspondingly decreased.

Fig. 3 illustrates Table V and makes graphic the more or less regular increase in the number of accidents during both the forenoon and afternoon periods of *uniform employment and of uniform speed of activity*. The fall in the number of accidents following the noon period of rest is striking. When it is recalled that Table V and Fig. 3 apply only to those accidents

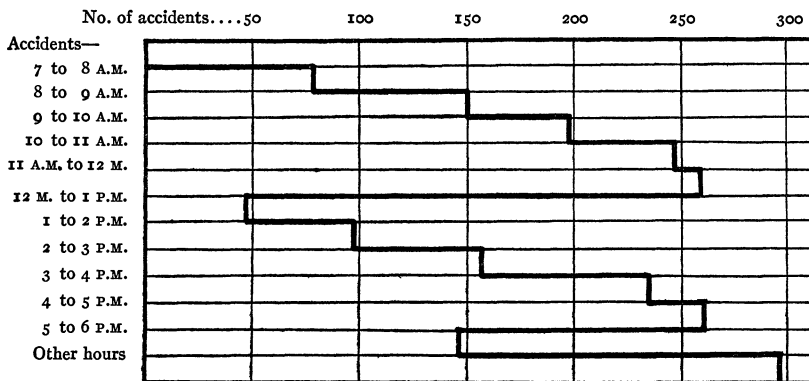


FIG. 3

(Class B) which were immediately preceded by muscular inaccuracies of small proportion (see Section III), further illumination thus will be given to the law of fatigue as stated at the close of Section III; namely, that the increasing muscular inaccuracy accompanying uninterrupted work results *in increasing numbers of accidents*.

The question of accident-hours has hardly been raised as yet in the United States. Only a few states, such as Wisconsin, Minnesota, and Illinois, require that the exact time of accidents be reported to the offices of factory inspection. At best, statistics of accident-hours in the United States are unsatisfactory. Table VI is prepared from the accident records of Wisconsin for the year 1907-8.⁴ It should be noted that in Table VI and in the tables of accident-hours which follow that all accidents

⁴ Bur. of Labor and Industr. Statis. (Wis.), *14th Biennial Report*, Part I (1907-8), 78.

are included—those due to the breaking of machinery, etc.; whereas in Table V (Illinois statistics) only those accidents are classified which conceivably might have been avoided if the injured parties had had accurate muscular control. The question is raised by the compiler of the Wisconsin figures why the largest

TABLE VI
ACCIDENT-HOURS (WISCONSIN, 1907-8)

Morning	Accidents	Afternoon	Accidents
7 to 7:59.....	156	1 to 1:59.....	247
8 to 8:59.....	244	2 to 2:59.....	407
9 to 9:59.....	427	3 to 3:59.....	435
10 to 10:59.....	486	4 to 4:59.....	446
11 to 11:59.....	376	5 to 5:59.....	277

number of accidents did not occur in the last hour of work. Since many establishments close at some point between 5 and 6 P.M. the lessened number of accidents for this hour may be accounted for in this way in large measure. The explanation for the relative decrease in the number of accidents from 11 to 12 P.M. may be threefold: (a) As in Illinois, there may be whole shifts of men and women who take their lunch period at 11:30 A.M., and hence are not working during the last half-hour; (b) There presumably is a slackening of the rate of work with a correlative decrease in danger of accident; (c) Some workmen with a surplus of energy may experience the "final spurt" and thus the danger of accident may be lessened.

At all events, a consideration of the Wisconsin statistics for the hours of uniform employment and uniform rapidity from 8 to 11 A.M. and from 1 to 4 P.M. would eliminate many extraneous elements and justify the conclusion, as in the case of the Illinois statistics, that fatigue is a causal factor in accidents.

Table VII shows the distribution of accidents through the day in New England and southern cotton mills.⁵ The table includes figures from three series.

Of the three series presented, that of accidents in one New England mill for an eight-year period is the most significant, since it shows the comparatively unhindered operation of uniform causes. In this series the

⁵ *Op. cit.*, Senate Doc. No. 645. Vol. I, 395.

TABLE VII
ACCIDENT-HOURS (IN COTTON MILLS)

Morning	Accidents	Afternoon	Accidents
7:01 to 8.....	163	1:01 to 2.....	141
8:01 to 9.....	208	2:01 to 3.....	165
9:01 to 10.....	251	3:01 to 4.....	203
10:01 to 11.....	242	4:01 to 5.....	147
11:01 to 12.....	121	5:01 to 6.....	92

percentage of accidents gradually rises during the forenoon until 11 o'clock, and then there is a decided drop. In the afternoon the percentage remains comparatively low until 4 o'clock, when there is a considerable rise followed by a large decrease in the percentage during the last hour of the day. . . . The accident distribution is apparently a product of at least two factors. The worker in beginning gradually increases his speed, the result being a combination of increasing speed with growing fatigue. A basis is thus furnished for a growing accident rate. As already indicated, there is an increase in percentage of accidents both in morning and afternoon; but in the latter period the process is not repeated on the same scale as during the morning hours. The drop at the end of the period has several factors which vary from industry to industry. The fatigue is itself a large element in the result. It finally overcomes to a degree the driving energy which has kept up the speed.⁶

In presenting tables of accident-hours compiled from the records of nineteen establishments engaged in metal manufacture (a special inquiry made by the United States Department of Labor) and from the unpublished records of the Indiana department of factory inspection for two years, the Bureau of Labor says, by way of analysis of the figures:

It is evident that in the inter-relation of influences acting upon the situation now one and now another may be dominant. *The most constant factor will be fatigue.* It will be present in varying proportion in every case. It may act with the tendency to increase speed and thus to produce a greater number of accidents. It may in the end become so pronounced that speed is reduced and the accident rate lowered. (It should not be forgotten, however, that this lowered accident rate is presumably far higher than it would be were the laborer working at this reduced rate while yet unfatigued.)

There will be some tendency to minimize the factor of fatigue in the above process, because it is not a matter of acute sensation. It gradually upsets those nice adjustments of the living organism upon which depend efficient labor and the safety of the worker. . . . Reduce the alertness and

⁶ *Ibid.*

the exactness with which the body responds to the necessities of its labor, and by just so much have you increased the liability that the hand will be misplaced that fraction of an inch which means mutilation.

*The law of fatigue is a universal law. We may change its operation, but cannot eliminate the fact. . . . The weaker organism suffers soonest and most.*⁷

It may be well to note here the two methods of tabulating accidents according to hours. The unsatisfactoriness of both methods is due to the fact that accidents occurring from one to fifteen minutes before or after a given hour, say 8 A.M., are frequently reported as occurring at 8 A.M. In Table VII, accidents are tabulated from 7:01 to 8 A.M., etc., and accidents which really happen after eight o'clock and belong to the second hour are included in the record for the first hour of work. Thus to each hour-period of the day many accidents are accredited which really belong to the succeeding hour. Ten to eleven A.M. in Table VII, for instance, really means 10:15 to 11:15 A.M. or thereabouts, and the greatest number of accidents really occurred somewhat later in both the forenoon and afternoon periods than is indicated.

On the other hand, in Tables V and VI accidents have been tabulated from 7 to 7.59 A.M., etc. This method is incorrect in the other direction. Some accidents occurring shortly before 8 A.M. and in the first hour of work have been reported as occurring at 8 A.M., and hence are included in the record for the second-hour period. In the succeeding ten tables both methods have been used, as far as the writer can determine. On the whole, it appears that the inaccuracies of the two sets of errors to a certain extent counterbalance each other.

The Minnesota Bureau of Labor has recently published a table giving a classification of hours of the accidents which were reported to the Bureau during the year August 1, 1909, to July 31, 1910. In commenting on this table the Bureau says:⁸

Fatigue and nerve strain also have a place among the causes of accidents and the table and chart below (see *Report*) suggest that it may be an important place. The question should be given further consideration.

⁷ *Op. cit.*, Senate Doc. No. 645. Vol. I, 395.

⁸ Bureau of Labor, etc. (Minn.), *12th Biennial Report* (1909-10), 137, 140.

The curves seem conclusive that . . . fatigue largely explains the lapse of attention that causes injury in the later portion of the working period.

In the study of accident-hours, European countries, notably France and Germany, are far ahead of the United States. In France, a study of accident-hours has been made by Professor A. Imbert of the University of Montpellier. He found that a study of 5,534 accidents distributed among 140,407 workers in the *circonscription de Toulouse* gave results similar to those indicated by Table VIII. These statistics apply to wood-workers, the chemical industries, building trades, etc. Table VIII refers

TABLE VIII
ACCIDENT-HOURS (FRANCE, 1904)

Morning	Accidents	Afternoon	Accidents
7 to 8.....	232	1 to 2.....	132
8 to 9.....	305	2 to 3.....	310
9 to 10.....	340	3 to 4.....	421
10 to 11.....	478	4 to 5.....	513
11 to 12.....	292	5 to 6.....	254

to the year 1904, represents all industries, and covers the departments of Herault, Aveyron, Lozere, Cantal, and Tarn.⁹ Imbert interprets these figures as follows:

A large number of accidents result directly from the physical or mental fatigue of the workmen at the moment of the accident and this assertion can easily be proved by innumerable instances. . . . One result . . . is that fatigue renders the workman less apt to avoid accident since he cannot make ("ne peut plus réaliser") as intense an effort as usual nor execute movements of his normal rapidity. . . . Two facts are shown very clearly by this table of figures (see Table VIII); namely, the considerable share played by fatigue in producing accidents and the equally important influence, in the inverse sense, of the midday hour of rest.¹⁰

*Fatigue being the inevitable consequence of work, accidents inexorably increase from hour to hour.*¹¹

Imbert refers to the inquiries made by M. Le Roy, division factory inspector of Toulouse, for the years 1903 and 1904, and says that the results, which apply to several thousands of acci-

⁹ A. Imbert and M. Mestre, "Nouvelles statistiques d'accidents du travail," *Rev. Scientifique*, October 21, 1905, 521.

¹⁰ A. Imbert, "Les accidents du travail et les compagnies d'assurances," *Rev. Scientifique*, June 4, 1904, 715.

¹¹ See Footnote 7.

dents, are in harmony with his results ("toutes, sans exception, presentent les caractères généraux que nous avons énuméré cidessus"). An excerpt from M. Le Roy's analysis is subjoined.

It is indisputable, in fact, that *the more fatigued a worker is, the more liable he is to accident*. The accident is then the consequence of the combined results of physical depression, relaxed attention, and less rapid movements. . . . All these data and the various statistics to which reference has been made bring us necessarily to a consideration of fatigue as one of the chief causes of accidents. . . . This cerebral fatigue, due to monotonous, speeded-up labor, induces a nervous depression which is betrayed by inattention, very often resulting in accident. It is precisely *this form of fatigue that explains the increasing progression of accidents* with the progress of working hours in industries where work is most often limited to watching machinery.¹²

Germany was among the first nations to require that accident-hours be reported. Table IX is compiled from the German accident statistics for the years 1887 and 1891, and applies to all of the various trades and to agriculture combined. The accidents represented in Table IX appear to have been reported with more system than that shown in the reporting of accident-hours in other countries, with the possible exception of France. Table IX represents a wide and comprehensive range of accidents.¹³

TABLE IX
ACCIDENT-HOURS (GERMANY, 1887, 1891)

Morning	Accidents	Afternoon	Accidents
7 to 8	1,541	1 to 2	1,727
8 to 9	1,961	2 to 3	2,445
9 to 10	2,490	3 to 4	3,229
10 to 11	3,455	4 to 5	3,194
11 to 12	3,213	5 to 6	2,824

The results of the investigations made in Germany in the years 1897 and 1907 are similar in the main to those given in Table IX.¹⁴ Of the 81,284 accident cases reported for the year

¹² See Brandeis and Goldmark, *Ten-Hour Law for Women* (New York), 241, 242.

¹³ See E. R. Krejcsi, *8 Cong. Intern. d'Hyg. et de Demog.*, VII, 328; also the *24th Annual Report*, Commissioner of Labor (U.S.), Vol. I, 1132-34; also the *17th Annual Report*, New York Bureau of Labor Statistics, 730-939.

¹⁴ See *Ämtliche Nachrichten des Reichs-Versicherungsamts*, Beiheft I, Teil 1 (1910); also see *Bulletin of the Bureau of Labor*, No. 92 (January, 1911). It should be noted that these German statistics refer to fatal accidents and to those cases where the injured was disabled for more than thirteen weeks. They include the accident reports from the mining, quarrying, iron-and-steel, metal-working, textile, wood-working industries and from the building trades.

1907, 13.87 per cent occurred between the hours of 6 and 9 A.M., and 28.42 per cent between the hours of 9 A.M. and 12 M.; while 13.81 per cent happened between the hours of 12 and 3 P.M., and 26.32 per cent between the hours of 3 and 6 P.M. In regard to the 45,971 accident cases reported for the year 1897, the percentages of the accidents for the different sections of the day run approximately parallel with those given for the year 1907. For both years the increase in the number of accidents during the forenoon and afternoon periods is most pronounced in the metal-working trades. The percentages for the 424 accident cases reported in 1907 for the South German metal-workers were as follows: 12.89 per cent for the hours from 6 to 9 A.M., and 37.23 per cent for the hours from 9 A.M. to 12 M., and 11.93 per cent for the hours from 12 M. to 3 P.M., and 32.22 per cent for the hours from 3 to 6 P.M.

In England little attention has been given to accident-hours; a partial and inadequate list of accidents in factories and workshops for the year 1903 may be found in the *British Sessional Papers*, House of Lords.¹⁵ Table X gives the figures of a recent study of accident-hours in Belgium (1907) and applies to all industries.¹⁶

TABLE X
ACCIDENT-HOURS (BELGIUM, 1907).

Morning	Accidents	Afternoon	Accidents
7 to 8.....	500	1 to 2.....	136
8 to 9.....	454	2 to 3.....	403
9 to 10.....	586	3 to 4.....	787
10 to 11.....	835	4 to 5.....	504
11 to 12.....	675	5 to 6.....	568

In Copenhagen, Dr. H. Bille-Top kept a record for ten years (1898 to 1907) of the industrial-accident cases which he was called upon to attend—according to the hour of their occurrence.¹⁷ Dr. Bille-Top attributes the increase in the number of

¹⁵ Vol. LIX, 211.

¹⁶ Ministère de l'industrie et du travail, *Rapports annuels de l'inspection du travail* (1907), 212, 213.

¹⁷ H. Bille-Top, "Die Verteilung der Unglücksfälle der Arbeiten, die Wochentage und die Tagesstunden," *Centralbl. f. Allgemein. Gesundheitspf.*, XXVII, 197.

accidents in both the forenoon and afternoon periods to *increasing fatigue* ("zunehmender Müdigkeit, zunehmender Abgespanntheit").

Professor G. Pieraccini and Dr. R. Maffei, head physicians in the Royal Main Hospital, Florence, have made an investigation of the accidents (with reference to accident-hours) which took place in some of the railway machine-shops of Italy (1901 to 1905). The results of their tabulation of accident-hours are given in Table XI. They omit the first hour of work of both

TABLE XI
ACCIDENT-HOURS (ITALY)

Hours of Work	Accidents
2d.....	206½
3d.....	258
4th.....	324½
5th.....	323

periods of the day—because fewer workmen are at work than during the succeeding hours. The accidents for the corresponding hours of the forenoon and afternoon periods are added together. Professor Pieraccini concludes that the protraction of the hours of labor raises the number of accidents with each successive hour, in both the first and second half of the day.¹⁸

In Vienna, Dr. Leo Verkauf has made some investigation of accident-time in connection with insurance studies. His figures refer to those industries (in Austria) in which a short recess, sometimes of thirty minutes, is given at 10 A.M. and at 4 P.M.¹⁹ They show an increase in the number of accidents for the first three hours of the forenoon and of the afternoon periods. Without some sort of comparative basis covering the same industries, the effects of the recess are difficult to determine.

Many conditions in Europe are different from those in the United States. Yet the fact that European investigations are uniformly emphatic in the assertion that the danger of accident increases with continued work is most significant for the American situation. The fatigue effects of the great and feverish haste

¹⁸ See Brandeis and Goldmark, *op. cit.*, 252.

¹⁹ E. R. Krejcsi, *op. cit.*, 328.

at which things are done in the United States must be added to the regular fatigue effects of the more deliberate European methods of operation.

Table XII gives the statistics to which reference has been made in the preceding paragraphs. The totals appear at the bottom of the table. From these figures it is not possible to make a comparison of the number of accidents occurring in the forenoon with those of the afternoon because the Saturday and other half-holidays depress the afternoon totals and because the forenoon period is frequently of greater length than the afternoon period. No attempt has been made to tabulate accidents

TABLE XII
SUMMARY OF ACCIDENT-HOURS

Hours	7 to 8	8 to 9	9 to 10	10 to 11	11 to 12	12 to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6
Illinois	97	150	193	246	257	49	111	156	227	260	145
Wisconsin	156	244	427	486	376	94	247	407	435	446	277
U.S. (cotton mills)	163	208	251	242	121	67	141	165	203	147	92
Minnesota	380	538	653	573	226	233	439	634	590	412	159
Indiana, etc. . . .	818	1,072	1,332	1,137	765	368	943	1,054	1,199	899	353
France (for 1903) .	25	30	20	57	63	...	18	40	45	105	118
France (for 1904) .	232	305	340	478	292	50	132	310	421	513	254
Germany (for 1887)	794	815	1,069	1,598	1,590	587	745	1,037	1,243	1,178	1,306
Germany (for 1891)	747	1,146	1,421	1,857	1,623	738	982	1,408	1,986	2,016	1,518
Belgium	500	454	586	835	675	74	136	403	787	504	568
England	9	19	18	27	46	23	11	18	22	24	24
Denmark	11	12	16	20	34	5	9	14	26	29	20
Total	3,732	4,993	6,326	7,566	7,068	2,289	3,914	5,646	7,184	6,533	4,834

according to the days of the week. Not only are there insufficient statistics to be tabulated in this way, but the Sunday period of supposed rest introduces new and complex factors. The records for the day following pay-nights indicate that abnormal factors have entered. As far as accident records go which may be tabulated by the days of the week, they indicate a large number of accidents on Monday, a much less number on Tuesday, a gradual rise till the close of the week, when the number of accidents on Monday is exceeded. "In many industries, notably the iron and steel, mining, textile, and railway, the

number of accidents steadily increases from the first or middle of the week and attains a maximum for Saturdays."²⁰ Sunday recreation seems to unfit workmen for steady work on Monday, "but fatigue evidently plays a rôle also; for even on Monday the number of accidents between 9 A.M. and 12 M. is larger than between 6 and 9 A.M., even in proportion to the hours worked in the two periods."

Table XII gives the same general results as Table V (Illinois statistics): (a) A marked increase of accidents during the forenoon period; (b) A decided fall after the noon period; and (c) Another marked rise in the afternoon period. Accurate conclusions regarding fatigue effects must be confined to those work-hours when the number actually at work is uniform and when the rapidity of work is fairly uniform. The hours of uniform employment and of uniform rapidity of work as determined in the early portion of this section, are from 8 to 11 A.M. and from 1 to 4 P.M. On the basis of this analysis, Table XIII has been constructed; the figures have been taken from Table XII. The number of accidents for the first hour of the three-hour morning

TABLE XIII
ACCIDENT-HOURS (FINAL RESULTS)

	FIRST HOUR	SECOND HOUR	THIRD HOUR
	8 to 9 Morning + 1 to 2 Afternoon	9 to 10 Morning + 2 to 3 Afternoon	10 to 11 Morning + 3 to 4 Afternoon
Illinois	261	349	473
Wisconsin	491	834	921
U.S. Cotton Mills	349	416	445
Minnesota	977	1,287	1,163
Indiana	2,015	2,386	2,336
France (1903)	48	60	102
France (1904)	437	650	699
Germany (1887)	1,560	2,106	2,841
Germany (1891)	2,128	2,829	3,843
Belgium	590	989	1,622
England	30	36	49
Denmark	21	30	46
Italy	206	258	324
Total	9,113	12,230	15,064

²⁰ Bureau of Labor Statistics (New York), 786, XVII.

period of uniform employment and rapidity has been added to the number of accidents for the first hour of the afternoon period of uniform employment and rapidity, and so on. The more or less regular increase in the number of accidents, hour by hour, from 9,113 to 12,230 and from 12,230 to 15,064, indicates quite definitely the results of fatigue in terms of actual accidents—inasmuch as extraneous elements have been largely accounted for and not included in these figures.

Table XIII serves as a basis for the following conclusion: Continuous work, other things being equal, *is accompanied, hour by hour, by an increasing number of accidents.* Table XIII adds weight to the statement of the law of fatigue given at the close of Section III; *the increasing muscular inaccuracy which accompanies uninterrupted work results in increasing danger of accident.* Table XIII is offered in support of the thesis of this investigation, that *fatigue is a cause of industrial accidents.*

In the following section an attempt will be made to answer the question, Has fatigue attracted attention to itself to the extent that it has been indicted as a cause of accidents by men of judicial and conservative mind?

VI. JUDICIAL FINDINGS AND DECISIONS

The accident statistics presented in the preceding section were related mainly to the development of fatigue and to the increase of accidents during the regular ten-hour day. The figures for accidents occurring during overtime work are very inadequate. Light is thrown on this point from two important sources: (a) the reports of the Interstate Commerce Commission, and (b) the decisions of the courts. Although the material used in this chapter and gleaned from these two sources is largely incidental to the main function of these sources, it is for that reason of special value for this investigation. The overtime accident cases cited in this section are not intended to show the relative danger of working "overtime," since there is no adequate basis of comparison. The accident cases cited here are those apparently due to *fatigue of overwork* and *per se* are offered as additional evidence in defense of the thesis that fatigue

is a cause of accidents. No attempt has been made here to offer an exhaustive list of such cases. The purpose at this point is to cite cases which will establish the fact, not the quantitative extent, of fatigue resulting from working overtime as a cause of accidents.

For several years past the Interstate Commerce Commission has concerned itself with a study of railway accidents; its findings are published quarterly. An excerpt germane to this investigation follows:

In nearly or quite every bulletin that has been issued, it has been necessary to record one or more collisions due to the mistakes or negligence of men who have been on duty so many hours as to raise the supposition, if not the presumption, that they had become drowsy, if they had not actually fallen asleep; and cases in which enginemen are definitely reported as being asleep on duty are common.¹

Table XIV presents a list of fifty-four railway accidents compiled from the reports of the Interstate Commerce Commission. In these cases, the person or persons responsible for the accident had been on duty periods of time varying from eleven hours and nineteen minutes to thirty-nine hours and twenty-five minutes without intermission (except where noted).² In respect to the accidents tabulated, the Interstate Commerce Commission either states or directly implies that "the men at fault had been on duty an excessive number of hours."³ The implication is clear that the fatigue of overtime work was the chief cause of these accidents involving loss of life and property. The facts upon which Table XIV is based are submitted as proof from an angle different from that of the preceding chapters that fatigue is a cause of accidents. Typical illustrations of what happened directly previous to the occurrence of the given accidents are given:

Accident No. 8 (Table XIV). Flagman, who had been ordered to hold one of the trains, went into caboose to get red light; sat down to warm himself and dry his clothes; fell asleep; had been *on duty sixteen and a half hours*.

¹ Interstate Commerce Commission, *Report*, No. 18, 10.

² The size of Table XIV is such that limitations of space do not permit its publication. Its contents, however, are indicated here.

³ See Footnote 1.

Accident No. 30. Due to forgetfulness on the part of an engineman 21 years old who had been *on duty thirty-nine hours and twenty-five minutes.*

Accident No. 34. Operator fell asleep and failed to deliver meeting order; *on duty twenty-four hours.*

Accident No. 38. Engineman fell asleep and slept two minutes; had been *on duty twenty-one hours.*

Accident No. 32. (Forty-two killed and injured.) Operator turned east-bound passenger train on wrong delivery track. . . . He had been *on duty twenty hours and fifty minutes.*

Accident No. 40. Engineman fell asleep and passed automatic block signal set against him; also passed flagman; had been *on duty seventeen hours.*

Accident No. 41. Engineman (killed) disregarded flag; had been *on duty twenty-eight hours.*

Accident No. 46. (Fifty-six killed and injured.) Misplaced switch at meeting point. Brakeman had been *on duty twenty hours and forty minutes.*

Accident No. 53. (Eight killed and injured.) The conductor and flagman of the freight had been *on duty sixteen hours and fifty minutes.* The freight was delayed . . . the flagman was left at "D" to stop the north-bound train. . . . After remaining at this station about seven hours (the flagman) was sitting on the steps of a caboose of a freight train standing on the side track, with the lantern on one of the lower steps of the caboose between his feet. While so sitting he fell asleep and was not roused until the north-bound train came along and passed him (and ran into the delayed freight).

Table XIV includes fifty-four collisions and derailments in which the total number of killed and injured was five hundred and forty-one persons; the total damage to engines, cars, and roadbed was \$512,453. When the Interstate Commerce Commission gives as the chief cause in each of these instances the fact that the men at fault had been on duty an excessive number of hours, and when the circumstances preceding the given accidents are considered, the proof is strong that the fatigue of overwork was beyond doubt the causal factor. Table XIV presents *fifty-four concrete, important cases* in support of the proposition that fatigue is a cause of accidents.

Further testimony in defense of the thesis of this treatise has been obtained from decisions of the courts—this is presented in the paragraphs which follow. Seven cases will be cited here in which the courts have decided that fatigue was a cause of the given accidents.

(a) In the case of *Pennsylvania v. McCaffrey*, the Supreme Court of the State of Indiana held:

Unless it be that a master has a right to require a servant to stand at his post of duty without food or rest for nineteen hours every day, Sundays included, and that such conduct is not a breach of duty to the public as well as to its other servants, it follows that the appellant (the railway company) in this case has not performed its duty towards decedent without which it is liable *if this negligence was the proximate cause of his accident. That it was, it is clear.* The law of nature is inexorable in its demands. The cravings of hunger must be appeased. The laws of humanity declare that every man fit to be a member of a train crew must have three meals, some rest, and eight hours sleep a day. The appellee well says: "Deprived of these requisites of intelligent life, a soldier becomes a coward; a workingman a drone." Any being would lose his strength if worked a few months by the time schedule provided for this crew. Every statute and employers' rule is made in the presence of, and subject to the laws of nature. Hunger, thirst, and sleep are imperative; and when a schedule is made of nineteen consecutive hours of service on a train, and no provision is made by the company for their supply of food, it is understood that the employees must, of necessity, at times during the service, leave their places to get their meals. So that when the engineer and conductor left the train, after thirteen hours' service, on the day of the accident, to get their suppers it was *in obedience to this law of nature—an over-ruling necessity*, and was not, therefore, negligence on their part. They were not deserters, and their conduct cannot be characterized as offending habits.⁴

(b) In the case of *Galveston, H. & S.A. Ry. Co. v. Brown et al.*, the Court of Civic Appeals of Texas said:

In determining the question of Brown's negligence in going to sleep on his engine, the jury could consider a fact in evidence, viz., that he had been working for appellant for the five days and nights preceding this accident, and *was overworked to such an extent that sleep was unavoidable.* We think that when appellant so overworks one of its employees that he cannot be expected to stay awake, it ought not to be allowed to say that he was negligent in going to sleep, in a question affecting the observance of its rules.⁵

(c) The Supreme Court of the State of Indiana has handed down a decision of special importance in the case of the *Republic Iron & Steel Co. v. Ohlet*. Excerpts from this decision are given herewith.

At the time the plaintiff sustained the injury alleged, he had been working continuously, at the instance and request of the defendant, in the said factory, for a period of forty-eight hours, without any sleep; and when he was ordered by said foreman to hold the rod, by reason of his continuous

⁴ 38 N. E. Reporter, 67.

⁵ 59 S. E. Reporter, 930.

work, without sleep, he did not realize or appreciate the danger to which he was being subjected. . . . It is disclosed that after he had worked continuously some thirty-six hours in turning the rod, he informed Kelly, the foreman, that he did not believe he could endure the labor any longer; but the latter informed him that he must continue at work until the rod was finished. It is not reasonable to assert that a man who has labored continuously for a period of forty-eight hours without sleep, or for even a much shorter time, is in his normal condition, or that he under the circumstances can properly exercise all of the faculties or senses with which he is endowed. . . . A human being deprived of sleep for the period which appellee was *becomes dull in intellect and apprehension, and necessarily must be more or less unmindful of his surroundings.* . . . The jury had the right at least to consider this feature of the case, as bearing upon the question *whether, under all of the circumstances, appellee apprehended and appreciated the danger to which he was subjected.*⁶

(d) In the case of *Pelin v. New York Centr. and H.R.R. Co.*, the Supreme Court of New York, Appellate Division, Fourth Department, reversed the trial court's decision in favor of the defendant and held that there was sufficient evidence to warrant the jury in finding *that the injuries were due to exhaustion* of certain servants of the corporation, owing to their having been on duty twenty-four consecutive hours (in violation of the statute). The court also held that, although those directing the movements of a train-crew might reasonably have anticipated that the run on which the crew was engaged would not last twenty-four consecutive hours, the conditions of the business of the road having been such that the run could not be completed in less than such time, and an injury having resulted *from the exhaustion of the crew owing to the hours of work*, the corporation was liable. Says the court:

The statute is for protection of employees liable to be injured by the carelessness or oversight of co-employees, *caused by exhaustion* induced by long-continued application to work. . . . A railroad company with a crew out on a train for more than twenty-four hours may elect to have the trip completed by the same crew. If so it runs the risk of liability for any injuries sustained by any of its co-employees, and which is the proximate cause of exhaustion or inattention caused by such working overtime. . . . The jury had a right to say that the fact that the flagman was asleep was *due to over-exhaustion by reason of his protracted employment*, and that the collision might not have occurred had he been *in his normal wakeful condition.*⁷

⁶ 68 N. E. Reporter, 901.

⁷ N.Y. Supp., No. 92, 468.

(e) The case of the *Great Northern Railway v. Couture*, who was injured while engaged as a brakeman, is directly to the point. "The decision in the reported case is a novel one, and there are but few decisions upon the liability of a master for injuries caused by compelling him to work an excessive number of hours."⁸ The court says:

A master who keeps his servant continuously at work for an undue number of hours is liable in damages for an injury which the servant sustains in the ordinary discharge of his duty, in consequence of his inability, *from fatigue and exhaustion*, to use the requisite skill and care. [The company was held liable] not upon alleged grounds of having used a defective system of coupling, nor for an excessive rate of speed in bringing the cars together, but for keeping the young man at work for an unreasonable length of time without sleep. . . . It could not be otherwise than that his bodily strength was at that time *exhausted* and that *his mental faculties must have been rendered dull and his power of observation greatly weakened*. . . . The learned judge was right in holding the present appellants responsible . . . in the application of the well-known principle that the employer's care for his workmen must be proportional to the risk of the occupation in which he engages them. To exact the extra-hazardous risk of coupling the cars in this instance required a degree of supervision and care on the part of the railway company's officials, which they greatly neglected, in compelling Couture to perform that work at three o'clock in the morning, after a service of forty-eight hours, interrupted only by two breaks, one of six and one of two hours. We have no hesitation in adopting the learned trial-judge's conclusion in this respect, and we believe this *considerant* of his judgment was sufficiently warranted by the terms of the plaintiff's declaration.⁹

(f) In affirming the decision of a lower court in favor of L. W. Reed, administrator, in the case of *Reed v. Southern Railway Co.*, the court states:

The testimony tended to show that Reed had mistaken the time by reason of the fact that his watch had run down; but it likewise tended to show that *this was caused by the defendant in requiring or permitting Reed to operate his engine for forty-two consecutive hours* immediately preceding the collision, without rest, and for twenty-seven or twenty-eight hours without anything to eat. This was evidence of negligence [on the part of the Southern Railway Co.].¹⁰

(g) E. D. McCrary, a flagman in the employ of the Southern Railway Company, while lying on the outside of the tracks

⁸ 7 *Amer. and Eng. Annotated Cases*, 190.

⁹ *Ibid.*

¹⁰ 55 *S. E. Reporter*, 218.

(August 17, 1906) near Sheldon, S.C., presumably asleep, with his shoulders between the cross-ties and his head or a part of it on the rail, was killed by a passing freight. In the trial in the circuit court, the Southern Railway Company was charged with carelessness negligence

in requiring and permitting the said E. D. McCrary to act as flagman upon said train, and to go out as flagman on the trip upon which he was killed, when the said company through its agents in service, knew or could have known that the said E. D. McCrary was in such physical condition, owing to the want of sleep and rest as to render him unfit to perform the duties of flagman, . . . and in requiring the said E. D. McCrary to be and remain in the service of the defendant with scarcely any sleep or rest for such a length of time immediately preceding his death as was completely *to exhaust his physical and mental powers*, as to render him incapable of properly guarding himself, and the train upon which he was flagging, *against the dangers incident to the operation of trains*.

The defendants denied the allegation of negligence and wilfulness and interposed the defenses of contributory negligence and assumption of risk.¹¹

The jury rendered a verdict in favor of the plaintiff for \$9,500, and the defendant appealed. On June 25, 1909, the Supreme Court of South Carolina *affirmed* the judgment of the circuit court.

In the seven cases cited, the courts have decided that the respective accidents were due (a) not to negligence, but in obedience to a law of nature, i.e., in part to the demands of fatigue; (b) to the fact that the injured was overworked to such an extent that sleep, the result of overfatigue, was unavoidable; (c) to the fact that the injured because of fatigue had become dull in apprehension and unmindful of his surroundings; (d) to overexhaustion by reason of protracted employment; (e) as a consequence of the inability of the injured from fatigue and exhaustion to use the requisite skill and care; (f) to the fact that the fatal mistake of the injured was caused by the fatigue of overwork; (g) to the exhaustion of the physical and mental powers of the deceased.

The fact that fatigue has attracted attention to itself as a cause of accidents to the extent that such a conservative body as the judiciary will thus indict it, is noteworthy. The seven

¹¹ 65 S. E. Reporter, 3.

cases which have been summarized in the preceding paragraphs are not presented because of any legal points involved or for any reasons other than as a sevenfold argument in support of the thesis that fatigue is a cause of accidents.

In the following chapter, all the evidence thus far obtained—chemical, physiological, neural, psychological, industrial (as such), experimental, statistical, legal—will be brought together and offered as a unified whole in defense of the thesis of this investigation. The facts thus collated will be used as a basis for what appears to the writer to be the one best method of reform and of overcoming fatigue as a cause of industrial accidents.

VII. CONCLUSIONS

In this study it has been found (Section II) that continued work is accompanied by the using up of energy-giving material of the muscles and nerves and by the production and accumulation of toxic fatigue substances. As a result of these processes, muscles respond less and less accurately and the central nervous system becomes less and less efficient in its methods of control. At a certain point in the katabolic processes of the working muscle, inhibitory impulses are sent in to the cortical centers over the afferent nerves. These appear in consciousness in the form of sensations of effort, of strain, of fatigue which constitute warnings and which demand a change in the working mechanism. At the same time, the working muscle gradually becomes weaker, owing to the using up of its energy-giving material, and less responsive, owing to the paralyzing effect of the accumulating toxic substances. If the given activity is continued long enough or if continued for a shorter time with a high degree of unrelaxed tension, the cortical centers submit to katabolic processes and become less accurate in controlling peripheral movements. The combined phases of the fatigue process result in muscular inaccuracy extending from the immeasurably small blockings of the finely adjusted musculature on to the failure to make the grossest muscular contractions.

But the nervous system is so constructed that on occasion it can call out reserve strengths and for short, irregular periods of

time ward off disastrous fatigue effects. Thus the progressive loss of muscular control accompanying work is marked by irregularly appearing spurts and depressions. Upon these facts the law of fatigue is based which is so generally a fundamental explanation of the cause of accidents. Because knowledge of this law appears to be essential to a thorough understanding of industrial accidents, it is restated here: Uninterrupted work is accompanied by muscular inaccuracy which increases irregularly and at a rate dependent on the rate of activity and on the relative difficulty of the given work for the given individual.

Section III set forth the fact that the increasing muscular inaccuracy which accompanies work is greatly accelerated by the conditions peculiar to industrial conditions—by the monotonous and speeded-up operations, by the mental strain which comes from trying to attend to simple operations maintained at a terrific rate. When these conditions must be met for excessive hours without adequate rest periods, they lead to failure to make even the grossest co-ordinations—to sleep and exhaustion. Since a large proportion, especially of non-fatal injuries, occur in connection with dangerous machinery where a muscular inaccuracy of an inch or of a fraction of an inch results in mutilation of the operative, the facts thus far reviewed may be summarized in the statement that uninterrupted work is accompanied by increasing muscular inaccuracy, which in turn results in increasing chances of accident.

In the series of controlled experiments (Section IV), it was definitely shown that even in a short period of work involving monotony, speed, mental strain, where a high degree of volitional power might be called out for the full time, practically two-thirds of the muscular inaccuracies occurred in the last half of the period. When the rate of work in these experiments was increased and as long as the rate was a “speeded-up” one for the given individual, the number of errors was and remained abnormally increased; moreover, the abnormal increase developed quite generally in the second half of the work periods.

The results of these experiments show that fatigue is an ever-constant factor in continued work, that the appearance of this

constant factor in the foreground during a given work period depends in part on the rapidity of work. These results illuminate the proposition that uninterrupted work is accompanied by muscular inaccuracy which increases at a rate dependent on the rate of activity. When given an industrial interpretation, these results indicate that continued work in the dangerous trades is accompanied during each of the succeeding work periods by increasing chances of accident and at a rate correlative with the speed of work.

The statistics of the hours when accidents occur (Section V) show complex results. As a basis for conclusions work periods were taken when the factors of "warming up" and "final spurt" are eliminated, when a uniform number of people are at work, and when a fairly uniform degree of speed was maintained. Statistics for such work periods show a regularly and pronounced rise in the number of accidents from hour to hour. If extraneous factors are not included statistics of accident-hours indicate clearly that fatigue is a cause of industrial accidents. These statistics make possible a description of typical succession of events: (*a*) the development of fatigue due to monotonous, speeded-up work under a high pressure of mental strain maintained for long hours at a time; (*b*) the development of muscular inaccuracies due to this increasing fatigue; (*c*) increasing numbers of accidents due immediately to this increasing loss of muscular accuracy.

The case against fatigue of overwork is becoming so clear that it is receiving attention in the findings of such a group of men as compose the Interstate Commerce Commission and in the decisions of the conservative courts. Legal authorities have indicted fatigue as a cause of accidents and the related decisions have been presented (Section VI) in further defense of the thesis of this investigation.

In the preceding paragraphs the facts have been summarized upon which the thesis is maintained that fatigue is a cause of industrial accidents. A word of explanation is needed at this point. The accidents which formerly were bulked together and attributed to *carelessness* now receive a more careful explanation.

Dr. Emil Roth says that that which is often ascribed to the carelessness ("auf das Konto des Leichtsinns und der Nachlässigkeit") of the worker is in reality the result of oncoming fatigue.¹ Professor Adams states that this carelessness which has been alleged as a cause of accidents "we are now beginning to realize is often due to the mere stress and strain under which modern factory operatives work."² Carelessness is not an ultimate cause, says Elizabeth Butler in her study of *Women and the Trades*, but a resultant from any one of a multitude of things, one of which is the haste and disregard of personal risk resulting almost inevitably from a piece-work system.³

Crystal Eastman, who has made a study of the causes of those fatal accidents which are commonly spoken of as due to the "carelessness of the man injured," says that instead of 95 per cent, only 32 per cent of the fatal accidents can be laid in a measure to the responsibility of the victims; that of this 32 per cent, 11 per cent is not due to carelessness, strictly speaking, but to ignorance, youth, and physical weakness; that in the case of the remaining 21 per cent of the fatalities actually due to carelessness, some of the men were heedless, some inattentive, and some reckless.⁴

For the heedless ones no defense is made. For the inattentive we maintain that human powers of attention, universally limited, are in their case further limited by the conditions under which the work is done—long hours, heat, noise, intense speed. For the reckless ones, we maintain that natural inclination is in their case encouraged and inevitably increased by an occupation involving constant risk; recklessness is part of the trade. Not all accidents due to inattention and recklessness can be thus defended; but speaking generally these two kinds of carelessness cannot fairly be called faults of the workman.

So-called carelessness may be explained by the fact that the fatigued workman is unable to give as close attention to safety appliances and machine guards as a normally resistant workman can give. In their laundry investigation, Clark and Wyatt found

¹ Emil Roth, *14 Intern. Kong., etc.*, IV, 290.

² Adams and Summer, *Labor Problems* (Macmillan, 1908), 483.

³ Eliz. B. Butler, *Women and the Trades* (Charities Pub. Com., 1909), 108.

⁴ Crystal Eastman, *Work-Accidents and the Law* (Charities Pub. Com., 1910), 95.

that "each burn is due to carelessness," but that if the girls were to be careful, they would have to focus their minds on self-protection, instead of on the proper accomplishment of their tasks, and would also have to work at a lower rate of speed.⁵ Hence it is becoming evident that accidents which have been hastily and unscientifically classed as due to "negligence" or to "carelessness" are in reality due to the inexorable demands of the overworked human organism.

In concluding this summary, it may be added that as soon as it becomes evident that fatigue is a cause of accidents and as soon as the way in which fatigue causes accidents becomes clear, definite methods of prevention must be determined upon and put into operation. Society cannot afford to allow its industrial members to submit themselves unduly to the law of fatigue underlying accidents or to be coerced by external conditions in a similar fashion. Society cannot afford to permit wage-earners because of the fatigue effects of long hours of monotonous, speeded-up toil to be destroyed or even to be removed temporarily or permanently as means of support to large families (and the support of these families thus to be thrown upon the public).

The deaths and disablements due to fatigue represent a needless waste to society. Louis M. Greeley says that every day the enormous waste to society from industrial accidents becomes clearer, that the burden imposed upon public charity becomes heavier, and that the conviction becomes stronger that our present inaction in these matters must give place to intelligent action in order that these great evils be lessened.⁶

At this point, the question logically follows: What can be done to reduce the fatigue which causes accidents?⁷ The answer must be psychological and economic. Make it overwhelmingly to the financial advantage of employers to reduce to the narrowest limits the number of accidents that befall their

⁵ Clark and Wyatt, "Women Laundry Workers in New York," *McClure's*, XXXVI, 404.

⁶ L. M. Greeley, "Changing Attitude of the Courts toward Social Legislation," *Survey*, XXIV, 778.

⁷ It will be clear that the defense of the thesis of this investigation does not in itself call for an elaborate discussion of measures for prevention. Consequently, the suggestions made here will be presented only in outline form.

employees.⁸ The chief way to prevent fatigue-accidents effectively is to make the lives and limbs of his employees as important to an employer as the output.⁹ The all-important measure in minimizing fatigue-accidents appears to be *compulsory accident-insurance* (constitutionality granted, of course).¹⁰ This method of prevention works better than any other in Germany, and is described briefly by Professor Henderson:

The German industrial-insurance law requires the employers to pay one-third of the cost of sickness-insurance, and all the premiums for accident-insurance; the sickness-insurance fund cares for the disabled workman for thirteen weeks, after which the employers' fund pays for further support during disablement due to accident. Naturally, it is seen to *be to the interest of all parties to reduce the number of accidents to the lowest possible level* by taking all precautions suggested by experience. If a workman is careless he may be fined and thus disciplined to observance of the regulations made for his benefit. If a certain factory shows a high rate of injury to employees, its assessment is correspondingly raised by the executive committee. The accident-insurance law works automatically to reduce accidents.¹¹

(a) It is safe to say that when it becomes financially advantageous to employers to minimize danger of accident to employees they will replace monotonous and speeded-up hand-operations as far as possible by automatic processes. Piece-work in connection with dangerous machines will be supplanted by time-work. Miss Anderson, chief lady inspector in England, says that by cutting down piece-work the danger of accidents will be lessened. In laundries more than one manageress has been able to minimize the risk of accident by insisting on payment by time, not by piece.¹² It follows from the law of fatigue (Sec-

⁸ H. R. Seager, *Industrial Insurance* (Macmillan, 1910), 28.

⁹ Crystal Eastman, *op. cit.*, 106.

¹⁰ A problem for investigation arises at this point: What effect has compulsory accident-insurance in Germany had upon the number of accidents per year per thousand? Adequate data are not at hand whereby a definite answer can be given. The situation is exceedingly complex and many factors would have to be given consideration, some of which may be indicated. (1) Year after year employees are speeded up in order to secure an increasing output—and a higher accident rate would naturally result from higher rates of speed. (2) During the industrial development of a country, untrained and inexperienced workmen are constantly being added to the force—a fact which would tend to increase the accident rate. (3) Stricter control is exercised now than twenty-five or even ten years ago in reporting accidents. Many other factors might be mentioned.

¹¹ C. R. Henderson, "Wood-workers and Their Dangers," *World To-Day*, XXXVI, 976.

¹² A. M. Anderson, *Sess. Papers* (House of Lords, 1904), LIX, 201.

tion II), and from the results of the experiments (Section IV), that a *reduction in speed would mean a reduction in chances of accident*.

But in many industries a reduction in speed is hardly practicable—competition and economic demands are too strong. To reduce speed would seem a retrogression in industry. Where it is impossible to substitute automatic machines, the employer whose employees have been made as valuable to him as his output (by compulsory accident-insurance) will lessen the dangers of speed by shortening hours of work.¹³

(b) Under compulsory accident-insurance laws the employer would lessen the danger of accidents *by making hours of continuous work commensurate with the intensity and danger of the work*. Crystal Eastman says that *shorter hours*—an eight-hour day for all railroaders—is about the most important thing to reduce the number of accidents.¹⁴ In regard to the employees in the dangerous wire-mills, Miss Eastman says that one way to lessen danger of accident will be “to reduce the hours and shorten the shift.”¹⁵

Greater intensity of work necessitates longer periods of relaxation. If the strain of the work cannot be lessened, *the duration must be*. Think of the crane man (in the steel-mill) upon whose alertness and care depend the lives of several others. His is a hot, unpleasant, lonely job. There is no one to spell him. He cannot get down from his cab for any reason. And he works twelve hours every day in the year except Christmas and the Fourth of July. No steel company can maintain that it has done everything to prevent accidents until it has reduced the working hours of men in such responsible positions.¹⁶

(c) Men and women must not be allowed to work at speeded and dangerous machines according to personal ambition but *according to the physical ability of the given individuals*. This norm will be attained not by the methods of the ordinary factory inspector nor even by medical factory inspection, but ultimately by examinations including tests possibly similar to those described in Section IV *in which each individual receives expert attention*. The physically unfit for the more dangerous forms of work must be weeded out *by expert tests*; they must not be allowed as now

¹³ Crystal Eastman, *ibid.*, 74.

¹⁴ *Ibid.*, 33.

¹⁵ *Ibid.*, 86.

¹⁶ *Ibid.*, 74.

to assume the more dangerous forms of work from economic motives and be eliminated by the painful and costly method of accident; for here as elsewhere the law of the survival of the fittest holds. The physical ability (and mental alertness) of the worker and the hours of work must be proportional to the fatiguing character and danger of the work.

(d) Compulsory accident-insurance so regulated that the employee must contribute a certain percentage of the fund from which compensations are paid will enlist the strong forces of labor itself, from individual laborers as such, to the powerful labor unions, in a more successful fight against fatigue and other causes of accidents. When it is made to the financial advantage of both employee and employer to reduce accidents, safety appliances, for example, will be not only installed, but actually used. Employers and employees must use various methods of instructing new and uninitiated workers as to the subtle dangers of fatigue. "Ignorance permits accidents which might be prevented."¹⁷ The potential force of the labor union under rational control, as a means of securing education of employees in industrial hygiene, of securing shorter hours and more adequate rest periods, etc., would be aroused to activity if it were made to the financial advantage of the union to do so. The union, made up of the workers themselves, is always present to observe violations, which cannot be the case, for instance, with factory inspectors.

While a discussion of methods for prevention of fatigue as a cause of accidents does not properly belong here, it is maintained that a method worthy of consideration is compulsory accident-insurance—granted the constitutionality of such a procedure, of course. In other words, it is contended that in the prevention of fatigue as a cause of accidents, *the will of the employer is pre-eminently important, and the will of the employees expressed through labor unions under rational control is of next importance.*

¹⁷ C. R. Henderson, "Social Cost of Accident, Ignorance and Exhaustion," *Pamphlet No. 72*, National Child Labor Commission (New York, 1908).